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EFFECTIVENESS OF NEST TREATMENTS ON TICK INFESTATIONS IN THE EASTERN BROWN PELICAN

NANCY L. NORCROSS[1,2,3] AND ERIC G. BOLEN[1]

ABSTRACT.—This study examined the effectiveness of treating ticks (*Ornithodoros capensis*) infesting nests of Eastern Brown Pelicans (*Pelecanus occidentalis carolinensis*). The number of immature ticks on nestling pelicans was significantly less in treated than in control nests. Nest abandonment also was less in treated nests; however, in severely infested nests, treatments did not prevent abandonment. Nesting success and hematocrit measurements did not differ significantly between control and treated groups. *Received 13 November 2000, accepted 22 March 2002.*

Colony abandonment associated with excessive tick infestations is one factor that continues to negatively impact the reproductive success of Brown Pelicans (*Pelecanus occidentalis*; Terrence et al. 1985; Duffy 1983; King et al. 1977a, 1977b). Large colonies of nesting seabirds provide ticks and other parasites with a readily available supply of hosts for food, shelter, and reproduction (Duffy 1988). Ticks survive year round in nest cores and reused nesting material, which subsequently provide ticks access to a dependable food source in following years (Humphrey-Smith and Moorhouse 1981). This relationship may provide both immediate and long term negative impacts on the host population of nesting birds. Ectoparasites can cause brood mortality (Feare 1976, Chapman and George 1991), nest abandonment (Duffy 1983; King et al. 1977a, 1997b), and reduced fitness, as evidenced by slowed development and reduced hematocrit levels in colonies of Cliff Swallows (*Petrochelidon pyrrhonota*; Chapman and George 1991). Boulinier and Danchin (1996) suggested that the effects of tick infestation on the reproductive success of Black-legged Kittiwakes (*Rissa tridactyla*) may affect recruitment and breeding site fidelity, and consequently impact trends in host populations.

Nest abandonment is perhaps one of the most damaging effects of ticks. During 1975, Brown Pelicans nesting at Aransas National Wildlife Refuge in Texas abandoned nests before hatching. Subsequent inspections revealed large populations of ticks in the nests and surrounding area; these were *Ornithodoros capensis*, reported only once previously in the continental United States (King et al. 1977a). Brown Pelicans in California infested with the tick *O. denmarki* experienced years of low productivity associated with abandonment of eggs and young (King et al. 1977b).

In the southeastern United States, tick infestations have been linked to nest desertions of Eastern Brown Pelicans (*Pelecanus occidentalis carolinensis*) in North and South Carolina. More than 90% of the nests were abandoned in a heavily infested colony at Bird Key Stono, South Carolina, during 1987 (Wilkinson et al. 1994). Desertion also occurred at Marsh Island in Berkeley County, South Carolina, again associated with tick infestations (Keirans et al. 1992). Wilkinson et al. (1994) first noted tick-associated desertion of 80 nests on an island in the Cape Fear River of North Carolina during 1991. *Ornithodoros capensis* was collected from colonies of Brown Pelicans on North Pelican Island and Ferry Slip Island in the Cape Fear River in 1991 (Keirans et al. 1992).

The objectives of this study were (1) to compare tick populations in Brown Pelican nests treated with pesticide to those in nests left untreated on South Pelican and Ferry Slip islands, (2) to determine if tick populations adversely impact nesting success, and (3) to determine if tick infestations reduce hematocrit levels in nestling Brown Pelicans.

STUDY AREA AND METHODS

South Pelican Island (33° 56′ N, 77° 53′ W) and Ferry Slip Island (33° 58′ N, 77° 56′ W) in the Cape

[1] Dept. of Biology, Univ. of North Carolina, Wilmington, NC 28403, USA.

[2] Current address: 507 Troutwood Pl., Fuquay Varina, NC 27526, USA.

[3] Corresponding author; E-mail: ndaly@rkkengineers.com

Fear River of North Carolina served as study sites for this project. We selected nests at the beginning of the nesting season after egg laying began. During the 1998 season, nesting began in April. In 1999 pelicans began successfully nesting during May.

During 1998 we selected nests on each island by walking line transects across the island and alternately assigning nests as treated and control until we had a sample of 30 nests. Fifteen nests were treated with 1% diluted Rabon 50WP^R, a poultry spray that previously has been used to treat Brown Pelican nests in South Carolina (P. Wilkinson pers. comm.) and 15 nests were sprayed with tap water (control nests). We used garden spray containers to spray all nests, with spray directed underneath and around the eggs. We applied treatments twice during the incubation period during the 1998 nesting season and applied a third treatment on Ferry Slip Island approximately 1 week after chicks hatched, in an effort to obtain better tick control.

During the 1999 nesting season, we selected 60 nests on each island: 20 treated, 20 control, and 20 undisturbed (no application). Treated nests were sprayed with 0.5% Permectrin™ for the first two treatments, increased to 1% dilution for the third treatment to improve treatment effects. We applied three treatments on each island during the 1999 nesting season, two during incubation and one approximately 1 week after hatching. Control applications followed similar schedules during each season.

We monitored the number of eggs and chicks ≤2 weeks of age; chicks wander from the nest at 3–4 weeks of age. We visited each nest about once per week during 1998 and 2–3 times per week during 1999 to monitor nesting success. We considered those nests missing all eggs or with cold eggs and neither parent present to be abandoned. We calculated hatching success as the number of eggs hatched/eggs laid. We also calculated the number of young that survived to 2 weeks of age/number of young hatched. We calculated hatching success and percent surviving 2 weeks independently for each nest.

We examined each nestling in treated and control nests every 7–10 days following hatching for the presence of ticks; we did not examine nestlings on each visit to the colony in order to minimize disturbance. Counts of ticks and tick bites were restricted to the neck and beneath the wings of nestlings. We recorded tick infestations and nestling mortality for each nest until nestlings left the nesting area at approximately 3 weeks of age. We did not count ticks on nestlings in undisturbed nests.

We sampled blood from all nestlings in a subset of control and treated nests. Using a microhematocrit tube, we collected a drop of blood from the brachial vein. During 1998 we sampled nestlings approximately 1 week old from 10 control and 9 treated nests on South Pelican Island and from 10 control and 10 treated nests on Ferry Slip Island. During 1999 we sampled approximately 2-week-old nestlings from 8 control and 8 treated nests on each island.

During 1998 we collected nest material from all control, treated, and undisturbed nests on each island 2–4 weeks after chick departure. During 1999 we collected nest materials from abandoned nests immediately after noting abandonment and from all remaining nests 1–2 weeks after chick departure.

We placed nest materials in Berlese funnels (e.g., Bookhout 1994) positioned directly over 5-mm diameter jars containing 70% ethanol. Samples initially were heated from 48–72 h. Samples heated 48 h showed no difference in numbers of ticks collected relative to those heated 72 h, so all subsequent samples were heated 48 h. We then weighed the nest material to determine the number of ticks/kg dry weight. For those samples not run immediately, we placed a paper towel saturated in distilled water inside the plastic bag and stored the material in an incubator at 15° C until the samples were analyzed. We counted all ticks from each sample of nest material. Adult and nymph stages were not differentiated as both feed on pelicans and are distinguished only by the presence of a genital pore (Sonenshine 1991).

We compared control and treated nests separately by island and year. The number of ticks on nestlings was compared using the greatest mean number of ticks observed on all nestlings in a given nest over all dates (hereafter "tick intensity"). We compared hematocrit measurements for nestlings from control and treated nests using the mean for all chicks in the same nest. We tested the data for normality and data that did not meet normality criteria were analyzed using nonparametric statistics.

RESULTS

We never observed adult ticks on pelican nestlings. More immature ticks occurred on pelican nestlings in control nests than in treated nests. During 1998, tick intensity on nestlings ranged from 0–61. On South Pelican Island, mean tick intensity was 10.4 ± 3.7 SE ticks in control nests (n = 10) and 2.3 ± 1.2 SE ticks in treated nests (n = 12), a significant difference (Wilcoxon rank sums Z = 2.13, P = 0.03). On Ferry Slip Island, tick intensity was 12.6 ± 5.0 SE ticks in control nests (n = 12) and 1.7 ± 0.7 SE ticks in treated nests (n = 14; Z = 2.73, P = 0.006).

Whereas low levels of tick infestation occurred throughout 1998, tick numbers during 1999 were extremely low until mid-July, when the chicks reached approximately 2.5 weeks of age. At this time tick abundance increased markedly. Tick intensity during 1999 ranged from 0–100. On South Pelican Island, tick intensity was 20.1 ± 6.5 SE ticks in control nests (n = 11) and 4.2 ± 3.3 SE ticks in treated nests (n = 15; Z = 2.95, P = 0.003). On Ferry Slip Island, tick intensity was 12.8

± 5.3 SE ticks in control nests (n = 19) and 0.4 ± 0.2 SE ticks in treated nests (n = 19; Z = 4.08, $P < 0.0001$).

During 1998, no nest abandonment occurred in treated nests on either island whereas nest abandonment occurred in 40% of control nests on South Pelican Island (Pearson χ^2 = 7.5, df = 1, P = 0.01) and 27% of control nests on Ferry Slip Island (χ^2 = 4.6, df = 1, P = 0.03). During 1999 on South Pelican Island, two treated, three control, and three undisturbed nests were abandoned 2 weeks into the incubation period. Subsequent sampling revealed extremely high tick levels in these nests. There was no significant difference in abandonment among groups on South Pelican Island (χ^2 = 3.7 df = 2, P = 0.15) or Ferry Slip Island (χ^2 = 1.03, df = 2, P = 0.60).

During 1998, South Pelican Island control nests had a mean of 101.9 ± 62.0 SE ticks/kg nesting material and treated nests had a mean of 36.6 ± 12.8 SE ticks/kg (Wilcoxon rank sums Z = 0.0, P = 1.0). On Ferry Slip Island, control nests had a mean of 52.0 ± 28.5 SE ticks/kg and treated nests had 50.6 ± 15.7 SE ticks/kg (Z = 0.77, P = 0.44). During 1999, there was no significant difference in ticks/kg among undisturbed (mean = 81.4 ± 46.7 SE), control (mean = 70.7 ± 40.4 SE), and treated nests (mean = 44.1 ± 30.3 SE) on South Pelican Island (Kruskal-Wallis χ^2 = 2.71, df = 2, P = 0.26) or Ferry Slip Island (undisturbed: mean = 3.2 ± 0.9 SE; control: mean = 1.9 ± 0.5 SE; treated: mean = 2.4 ± 0.7 SE; χ^2 = 0.57, df = 2, P = 0.75). The series of abandoned nests on South Pelican Island ranged from 58–869 ticks/kg; consequently, these nests may have been infested with a total of 270–3910 ticks.

There were no significant differences in nestling hematocrit readings between control and treated groups during 1998 (mean hematocrit for South Pelican Island: 38.0% ± 1.3 SE for control nests and 39.3% ± 2.0 SE for treated nests, ANOVA F = 0.301, df = 18, P = 0.59; for Ferry Slip Island: 30.7% ± 1.6 SE for control nests and 31.1% ± 2.1 SE for treated nests, F = 0.031, df = 19, P = 0.86). There was a significant difference in hematocrit readings between islands (two-way ANOVA; Island: F = 8.83, df = 1, P = 0.005; Control/Treated: F = 0.26, df = 1, P = 0.61; there were no significant interactions: F = 0.05, df = 1, P = 0.82). During 1999, nestlings in control nests on South Pelican Island had a mean hematocrit of 38.3% ± 1.8 SE while those in treated nests had a mean of 38.6% ± 2.0 SE (ANOVA F = 0.016, df = 15, P = 0.90) and nestlings in control nests on Ferry Slip Island had a mean of 38.9% ± 1.4 SE while those in treated nests had a mean of 39.8% ± 2.4 SE (Wilcoxon rank sums Z = 0.26, P = 0.79).

Hatching success was similar for all groups on both islands during both years. During 1998, mean hatching success on South Pelican Island was 85.7% ± 6.7 SE for control nests (n = 7) and 88.9% ± 5.6 SE for treated nests (n = 9; Z = 0.31, P = 0.75) while mean hatching success on Ferry Slip Island was 86.7% ± 5.4 SE for control nests (n = 10) and 84.5% ± 6.2 SE for treated nests (n = 14; Z = 0.03, P = 0.97). During 1999, mean hatching success on South Pelican Island was 86.5% ± 4.6 SE for undisturbed nests (n = 16), 80.6% ± 6.4 SE for control nests (n = 12), and 79.2% ± 7.2 SE for treated nests (n = 16; Kruskal Wallis χ^2 = 0.538, P = 0.76) while mean hatching success was 84.2% ± 6.3 SE for undisturbed nests (n = 20), 88.6% ± 4.0 SE for control nests (n = 19), and 87.7% ± 5.1 SE for treated nests (n = 19; χ^2 = 0.066, P = 0.97).

There was no significant correlation between 2-week nest success and tick intensity during 1998 (Spearman r_S = −0.17, P = 0.30) or 1999 (r_S = −0.07, P = 0.61). Also during 1998, 2-week nest success did not differ significantly between control nests (90.5% ± 6.1 SE, n = 7) and treated nests (100%, n = 9) on South Pelican Island (Wilcoxon rank sums Z = 1.57, P = 0.12) or on Ferry Slip Island (control nests: 80.0% ± 6.9 SE, n = 10; treated nests: 81.0% ± 8.4 SE, n = 14; Z = 0.50, P = 0.62). There was a significant difference in total 2-week success between islands (Z = 2.04, P = 0.04). During 1999, mean 2-week success was 90.0% ± 4.5 SE for undisturbed nests (n = 15), 94.4% ± 3.7 SE for control nests (n = 12), and 93.3% ± 3.6 SE for treated nests (n = 15) on South Pelican Island (Kruskal Wallis χ^2 = 0.53, df = 2, P = 0.77) while mean 2-week success was 90.2% ± 3.8 SE for undisturbed nests (n = 17), 91.2% ± 4.3 SE for control nests (n = 19), and 90.4% ± 4.7 SE for treated nests (n = 19) on Ferry Slip Island (χ^2 = 0.236, P = 0.89).

DISCUSSION

During both 1998 and 1999, treatments effectively reduced the number of immature ticks infesting pelican nestlings, which suggests that nest treatments can control tick populations. Greater tick intensities were observed later in the season each year, but this was most obvious during 1999. While no visible ailments were apparent in chicks carrying large tick loads, the additional burden of ticks may further limit chick survival during years when other stresses affect reproduction. In addition, *Ornithodoros capensis* carries five different viruses (Yunker et al. 1979), although the effects of these on their hosts are largely unknown (Feare and Gill 1997).

In a similar study of *Argas* [*Persicargas*] *robertsi* infestation on Cattle Egrets (*Bubulcus ibis*), McKilligan (1996) observed a nesting season in which all chicks with tick loads exceeding 24 ticks/nestling subsequently died. Cattle egrets in infested nests experienced significantly greater mortality than those in treated nests (which were completely free of ticks) during the first season whereas no difference occurred during the second season. Tick loads were extremely variable within and between years, with much lower levels of infestation occurring during the second season. A similar pattern occurred in the present study, with some chicks having in excess of 100 ticks and many chicks having no ticks.

Our finding of no significant difference in hatching success or 2-week success among undisturbed, control, and treated nests suggests that the levels of nest infestation on the islands were not great enough to severely impact the nestlings. In contrast, Chapman and George (1991) recorded higher fledgling success from treated Cliff Swallow nests than from untreated nests. The swallow bug (*Oeciacus vicarius*) was the most abundant of four ectoparasites (three species of which were ticks) affecting these colonies. Richner et al. (1993) detected no differences in hatching success between nests with and without the hen flea (*Ceratophyllus gallinae*) in Great Tits (*Parus major*), although fledgling success was higher in nests free of these parasites.

Although we found no significant difference in the number of ticks collected from nests in undisturbed, control and treated nests, it is possible that ticks residing deep in the core of the nest were beyond reach of the pesticide. While examining infestations of *Ornithodorus amblus* in Guanay Cormorant (*Phalacrocorax bougainvillii*) nests in Peru, Duffy (1983) observed more ticks in the nest base than the nest cup. In addition, Duffy and Daturi (1987) observed strong diel patterns in the activity of *O. capensis*, in which the ticks were much more active during night than day. If adult ticks were deep within pelican nests when the treatments were applied, it is possible the treatment did not effectively reach those deep within the nest core. The treatments appeared to be much more effective on immature ticks, as would be expected because they reside closer to the nest surface.

Nest abandonment can play a large role in a colony's total reproductive success. Duffy (1983, 1988) described an abandonment "wave" that moved throughout a colony of Peruvian seabirds, which subsequently left eggs available to hungry gulls. For those nests containing chicks, subsequent mortality followed from exposure, starvation, or parasites. Similarly, King et al. (1977b) described nest abandonment as a gradual process moving through colonies of California Brown Pelicans and noted that abandonment was largely responsible for low reproduction in the Gulf of California during previous years. In our study, the severity of tick infestation in the abandoned nests and the progressive abandonment suggest that the abandonment was, at least in part, tick related.

In contrast to our study, ectoparasites significantly affected hematocrit levels in Cliff Swallows (Chapman and George 1991), Cattle Egrets (McKilligan 1996), and Great Tits (Richner et al. 1993). Wanless et al. (1997) observed that in Black-legged Kittiwakes, lower hematocrit values were related to higher tick levels, but in Common Murres (*Uria aalge*) they were not. Whereas tick loads in the present study did not appear to have adverse physiological effects, this nonetheless may occur in more severe infestations. W. Golder and J. Brunjes (pers. comm.) observed that infestations during past seasons in this study area have been much more severe as evidenced by red, irritated skin rashes on chicks. In such a situation, ticks may reduce chick fitness and

predispose chicks to adversities from other environmental stresses.

Wolf et al. (1985) recorded a mean hematocrit of 44.4% ± 1.1 in eight hatch-year captive Brown Pelicans. While this is higher than values measured in the present study, our hematocrits values were still above levels indicating anemia (>35%; Campbell and Morton 1984), with the exception of Ferry Slip Island during 1998. On Ferry Slip Island during 1998, hematocrit values were significantly lower in both control and treated nests. There are several possible explanations for this. First, higher temperatures can result in lower hematocrit readings (Kubena et al. 1972, Moye et al. 1969); the pelicans on Ferry Slip Island began nesting later, during warmer temperatures. Second, J. Brunjes (pers. comm.) noted that while food supplies appeared abundant at the beginning of the 1998 season, they appeared to decrease as the season progressed. Nesting on Ferry Slip Island during 1998 began approximately 4 weeks after South Pelican Island. It is possible that the lower hematocrit readings reflected the stresses from low food supplies. This also may explain the lower 2-week nesting success in both control and treated nests on Ferry Slip Island during 1998, as food supplies can significantly impact reproduction in Brown Pelicans (Anderson et al. 1982).

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